Use of Harel State Charts in the DoD High Level Architecture Interface Specification

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HLA Has Three Components

- Design Principles: Principles and conventions which must be followed to achieve proper interaction of federates during a federation execution. These describe the responsibilities of federates and of the interoperation facility in HLA federations.

- Object Model Templates: The prescribed common method for describing the entities to be simulated and interactions between entities in the federation.

- Interface Specification: Definition of the interface between the runtime infrastructure (RTI) and the federates in an HLA federation.

The HLA Interface Specification Structure

- **Provides a specification of the functional interfaces between federates and the RTI**
  - **Interfaces are divided into six service groups**
- **Each service specification includes:**
  - **Name and Descriptive Text**
  - **Supplied Arguments**
  - **Returned Arguments**
  - **Pre-conditions**
  - **Post-conditions**
  - **Exceptions**
  - **Related Services**
- **Application Programmer Interfaces (APIs) in CORBA IDL, C++, Ada'95 and Java**

More is Needed

- To motivate the need for state charts, the Ownership Management service group will be described using the techniques found in Interface Specification 1.0, 1.1, and 1.3
- This will demonstrate that certain questions are not addressed by those techniques
- One of the state charts found in Interface Specification 1.3 will be presented to show how it address these unanswered questions

General Description of Ownership Management

- Allow federates to transfer ownership of object attributes
  - Federates transfer ownership based on federation execution design plans
  - RTI arbitrates transactions so that ownership is held by at most one federate at any time
  - Offers both ‘push’ or ‘pull’ based transactions
  - Acquisition requires current publication declarations for attribute
  - Ownership acquisition attempts can be both ‘invasive’ or based on ‘opportunity’
- Interface functions include
  - Attribute Ownership Divestiture (unconditional and negotiated)
  - Attribute Ownership Acquisition (explicit and if available)
  - Query Attribute Ownership

Ownership Management Services

7.2 Unconditional Attribute Ownership Divestiture

7.3 Negotiated Attribute Ownership Divestiture

7.4 Request Attribute Ownership Assumption †

7.5 Attribute Ownership Divestiture Notification †

7.6 Attribute Ownership Acquisition Notification †

7.7 Attribute Ownership Acquisition

7.8 Attribute Ownership Acquisition If Available

7.9 Attribute Ownership Unavailable †

7.10 Request Attribute Ownership Release †

7.11 Attribute Ownership Release Response

7.12 Cancel Negotiated Attribute Ownership Divestiture

7.13 Cancel Attribute Ownership Acquisition

7.14 Confirm Attribute Ownership Acquisition Cancellation †

7.15 Query Attribute Ownership

7.16 Inform Attribute Ownership †

7.17 Is Attribute Owned By Federate

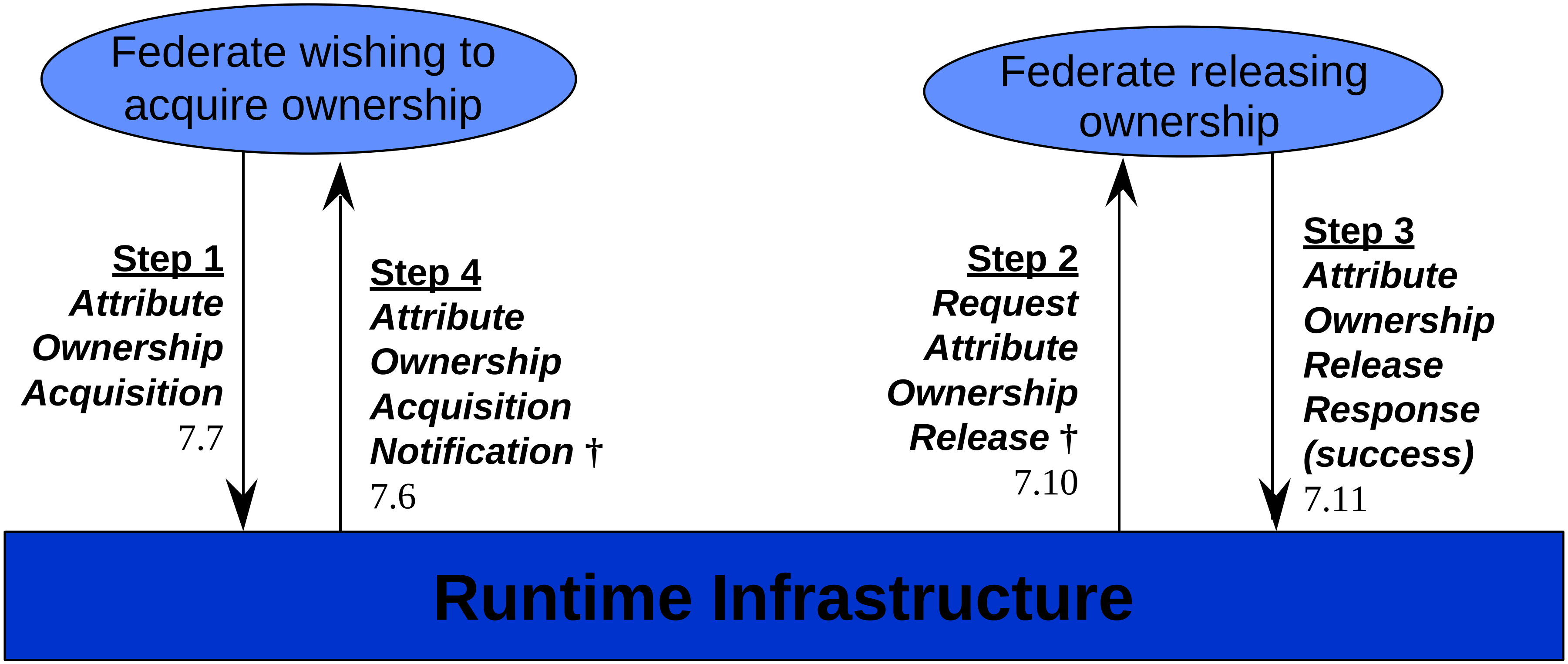
Example Service Description

Attribute Ownership Acquisition

The *Attribute Ownership Acquisition* service shall request the ownership of the specified instance attributes of the specified object instance. If a specified instance attribute is owned by another federate, the RTI shall invoke the *Request Attribute Ownership Release* † service for that instance attribute at the owning federate. The federate may receive one or more *Attribute Ownership Acquisition Notification* † invocations for each invocation of this service.

A request to acquire ownership shall remain pending until either the request is granted (via the *Attribute Ownership Acquisition Notification* † service) or the requesting federate successfully cancels the request (via the *Cancel Attribute Ownership Acquisition* and *Confirm Attribute Ownership Acquisition Cancellation* † services).

Ownership Acquisition



Federate wishing to acquire ownership

Federate releasing ownership

Step 1
Attribute Ownership Acquisition
7.7

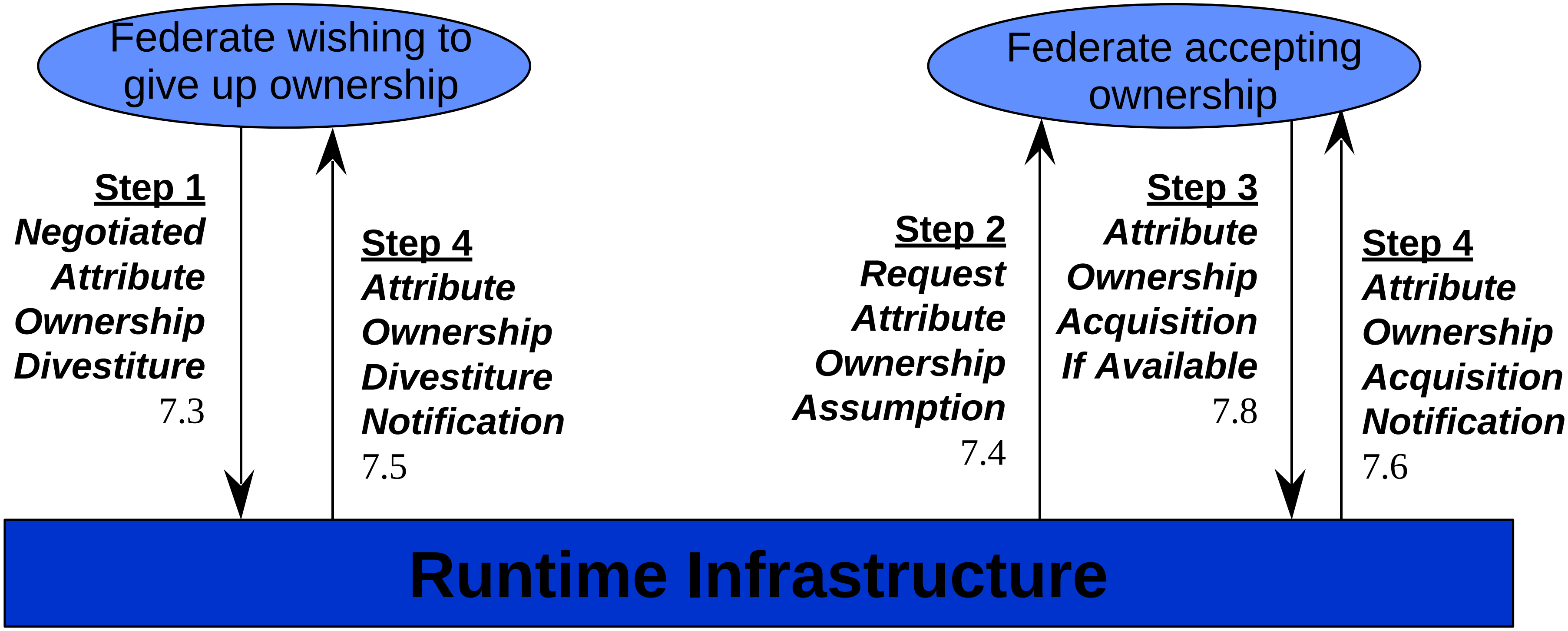
Step 4
Attribute Ownership Acquisition Notification †
7.6

Step 2
Request Attribute Ownership Release †
7.10

Step 3
Attribute Ownership Release Response (success)
7.11

Runtime Infrastructure

Ownership Divestiture (Negotiated)


Federate wishing to give up ownership
Federate accepting ownership
Step 1 ***Negotiated Attribute Ownership Divestiture*** 7.3
Step 4 ***Attribute Ownership Divestiture Notification*** 7.5
Step 2 ***Request Attribute Ownership Assumption*** 7.4
Step 3 ***Attribute Ownership Acquisition If Available*** 7.8
Step 4 ***Attribute Ownership Acquisition Notification*** 7.6
Runtime Infrastructure

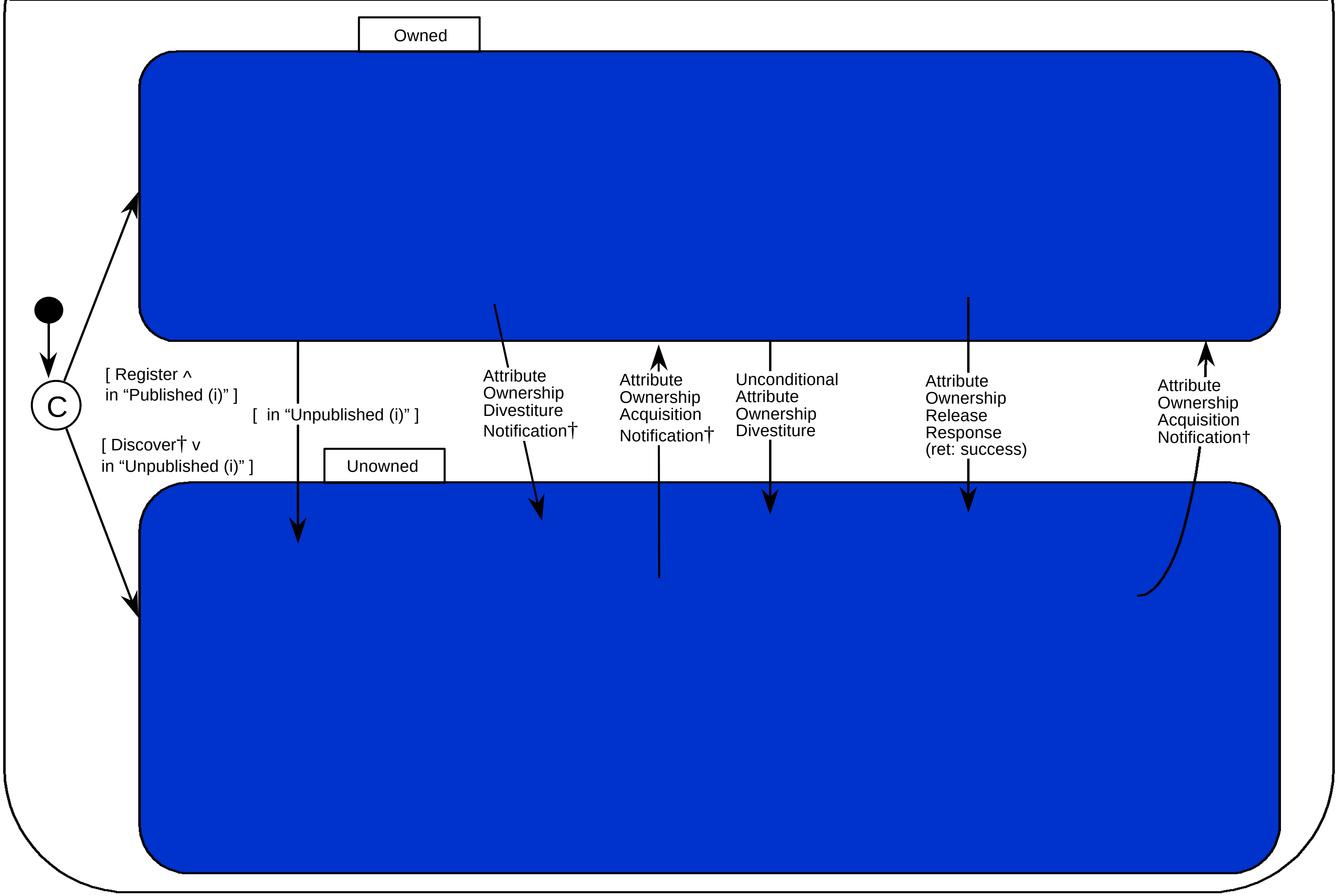
Does This Tell Everything ?

- The illustrations are very simple
  - Only two federates depicted
  - The desire to acquire/divest ownership was not canceled
- What is the relationship to
  - Declaration management?
  - Object management?
- Something is needed that covers every case

The Utility of State Charts

- The Interface Specification describes each individual service
- Introductory material in each section helps relate the individual services to give a picture of how they work together
- The state charts describe the conditions under which a federate may:
  - Update/Reflect attribute values
  - Send/Receive Interactions
  - Acquire/Divest attribute ownership
  - Etc.
- All discussion is from the perspective of a given federate
- The conditions are determined strictly by RTI services calls made by the federate and federate services calls made by the RTI
- State transition diagrams are used to present these conditions

Establishing Ownership of Instance Attribute(i)



Owned

Unowned

C

[Register ^
in “Published (i)”]

[in “Unpublished (i)”]

[Discover† v
in “Unpublished (i)”]

Attribute
Ownership
Divestiture
Notification†

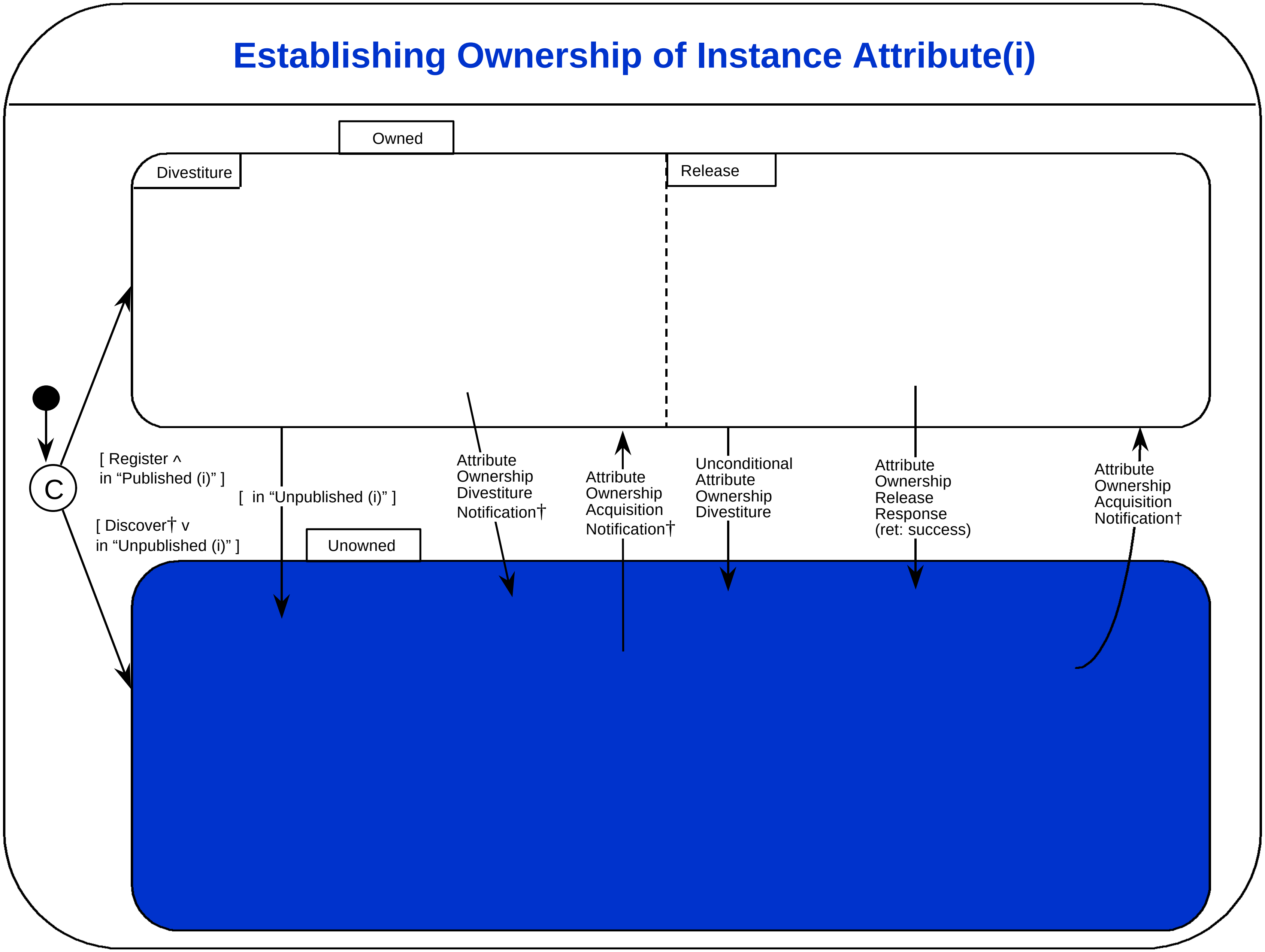
Attribute
Ownership
Acquisition
Notification†

Unconditional
Attribute
Ownership
Divestiture

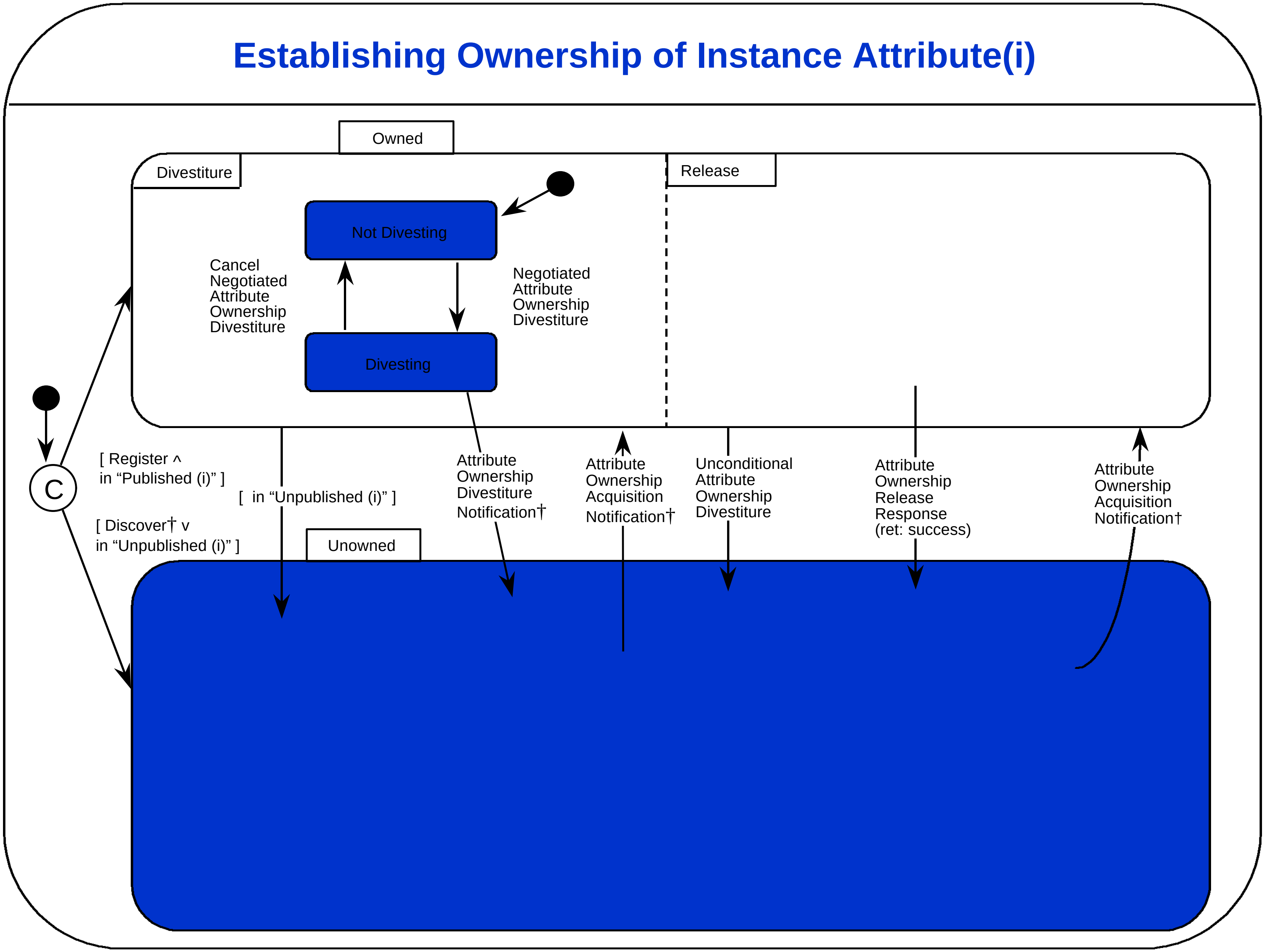
Attribute
Ownership
Release
Response
(ret: success)

Attribute
Ownership
Acquisition
Notification†

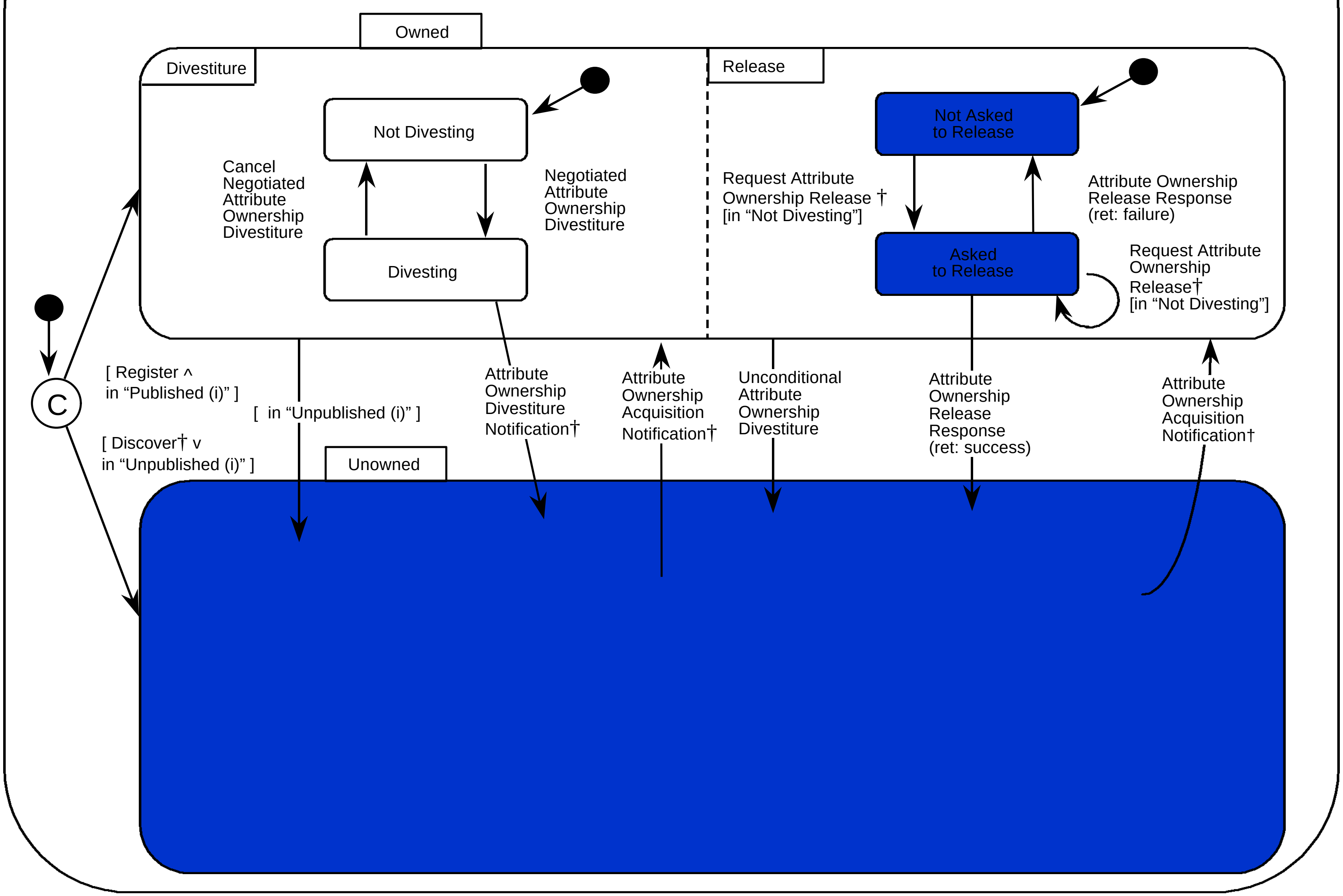
Establishing Ownership of Instance Attribute(i)



Establishing Ownership of Instance Attribute(i)


Owned
Divestiture
Release
Not Divesting
Divesting
Cancel Negotiated Attribute Ownership Divestiture
Negotiated Attribute Ownership Divestiture
C
[Register ^ in “Published (i)”]
[in “Unpublished (i)”]
[Discover† v in “Unpublished (i)”]
Attribute Ownership Divestiture Notification†
Attribute Ownership Acquisition Notification†
Unconditional Attribute Ownership Divestiture
Attribute Ownership Release Response (ret: success)
Attribute Ownership Acquisition Notification†
Unowned

Establishing Ownership of Instance Attribute(i)



Owned

Divestiture

Not Divesting

Divesting

Cancel
Negotiated
Attribute
Ownership
Divestiture

Negotiated
Attribute
Ownership
Divestiture

Release

Not Asked
to Release

Asked
to Release

Request Attribute
Ownership Release †
[in “Not Divesting”]

Attribute Ownership
Release Response
(ret: failure)

Request Attribute
Ownership
Release†
[in “Not Divesting”]

C

[Register ^
in “Published (i)”]

[in “Unpublished (i)”]

[Discover† v
in “Unpublished (i)”]

Attribute
Ownership
Divestiture
Notification†

Attribute
Ownership
Acquisition
Notification†

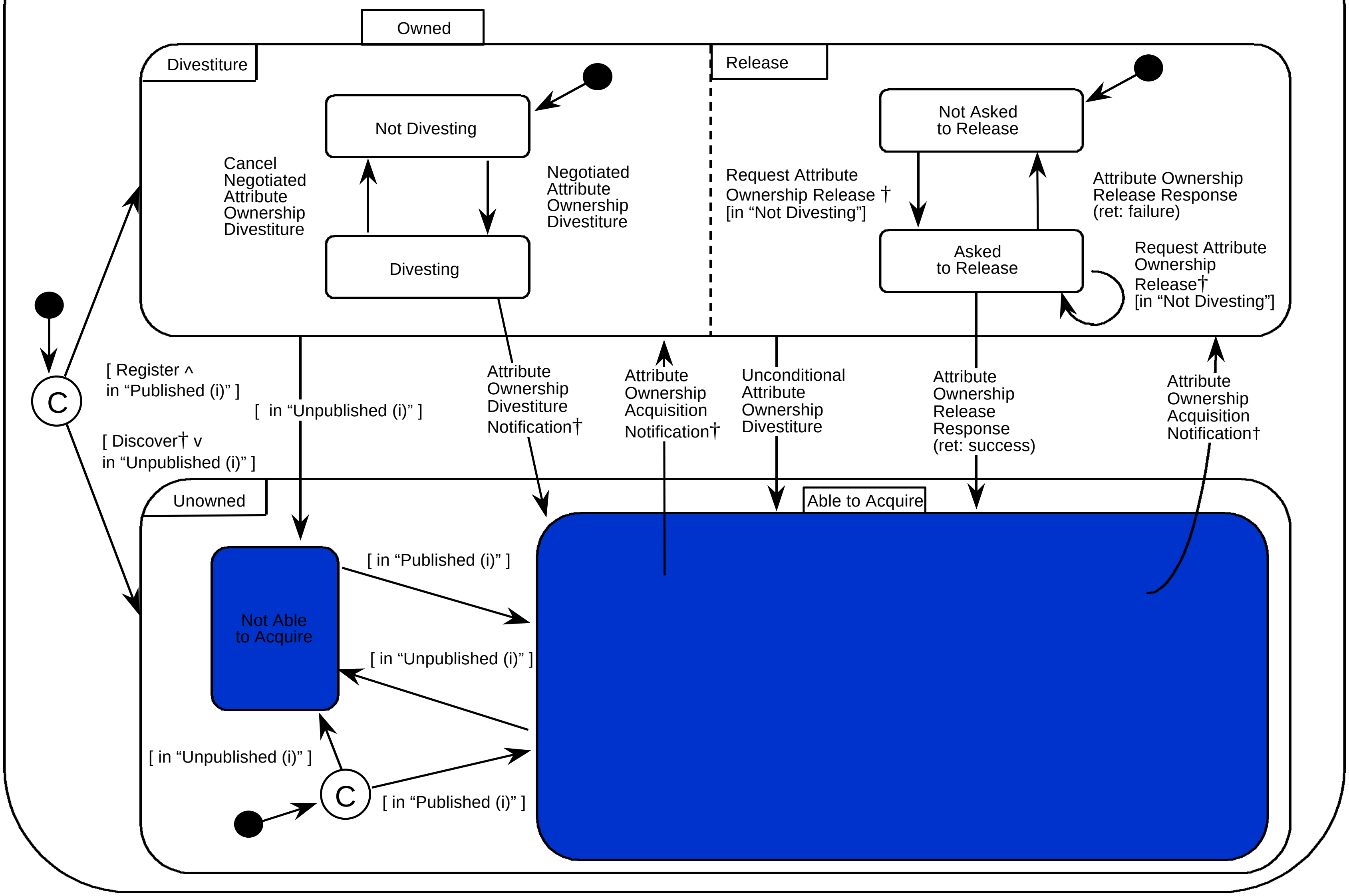
Unconditional
Attribute
Ownership
Divestiture

Attribute
Ownership
Release
Response
(ret: success)

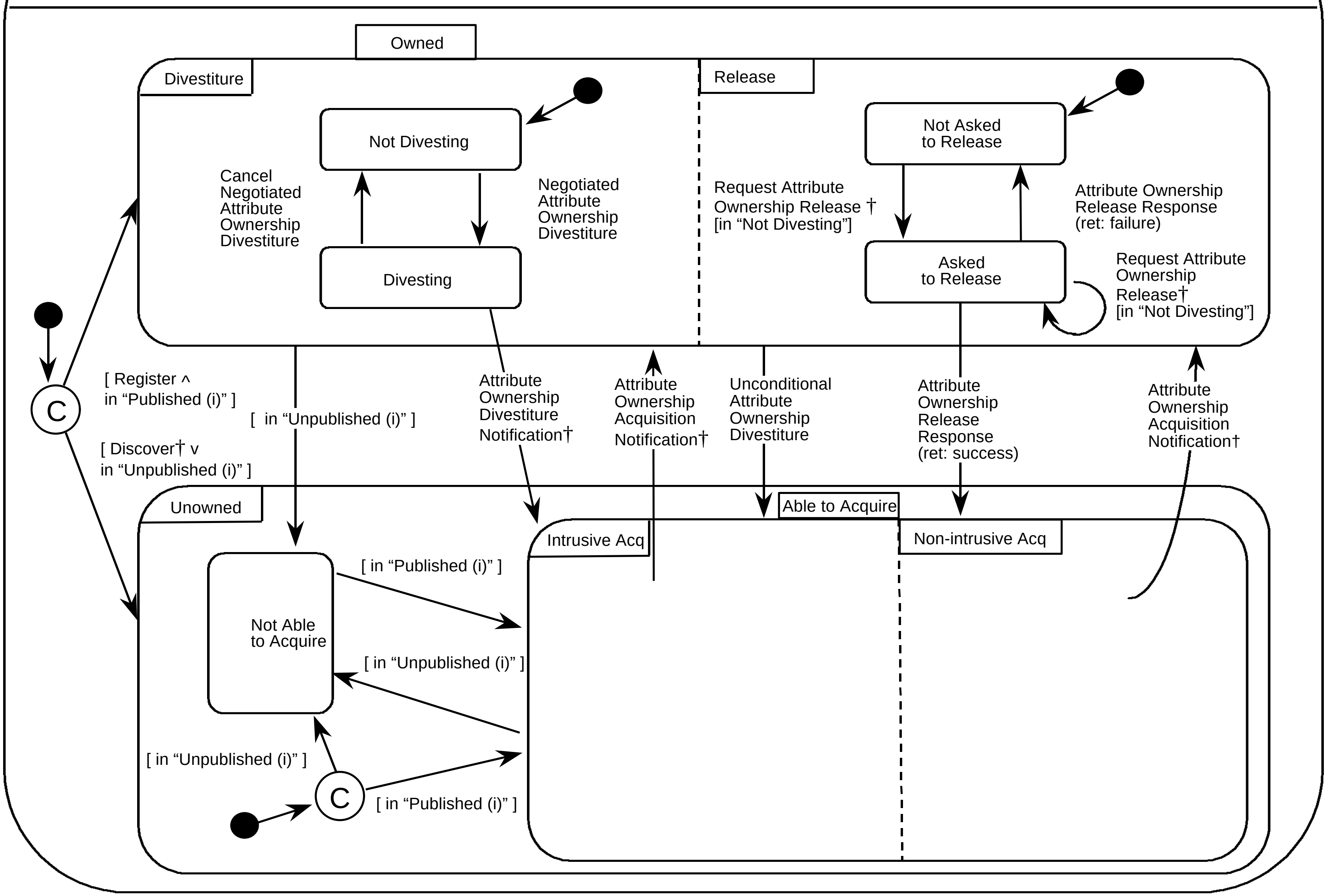
Attribute
Ownership
Acquisition
Notification†

Unowned

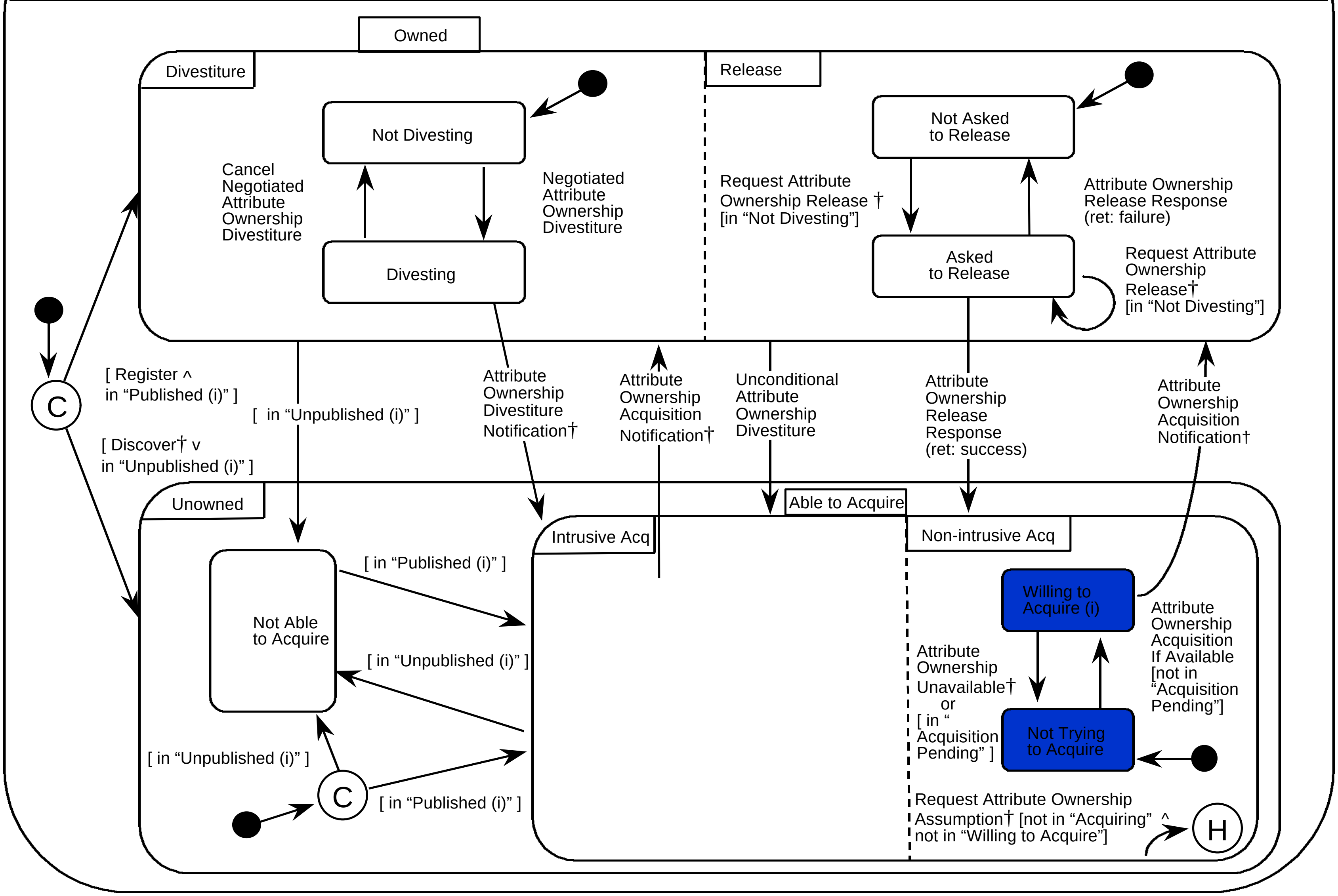
Establishing Ownership of Instance Attribute(i)


Owned
Divestiture
Not Divesting
Divesting
Cancel Negotiated Attribute Ownership Divestiture
Negotiated Attribute Ownership Divestiture
Release
Not Asked to Release
Asked to Release
Request Attribute Ownership Release †
[in “Not Divesting”]
Attribute Ownership Release Response (ret: failure)
Request Attribute Ownership Release†
[in “Not Divesting”]
C
[Register ^ in “Published (i)”]
[Discover† v in “Unpublished (i)”]
[in “Unpublished (i)”]
Attribute Ownership Divestiture Notification†
Attribute Ownership Acquisition Notification†
Unconditional Attribute Ownership Divestiture
Attribute Ownership Release Response (ret: success)
Attribute Ownership Acquisition Notification†
Unowned
Able to Acquire
Not Able to Acquire
[in “Published (i)”]
[in “Unpublished (i)”]
[in “Unpublished (i)”]
C
[in “Published (i)”]

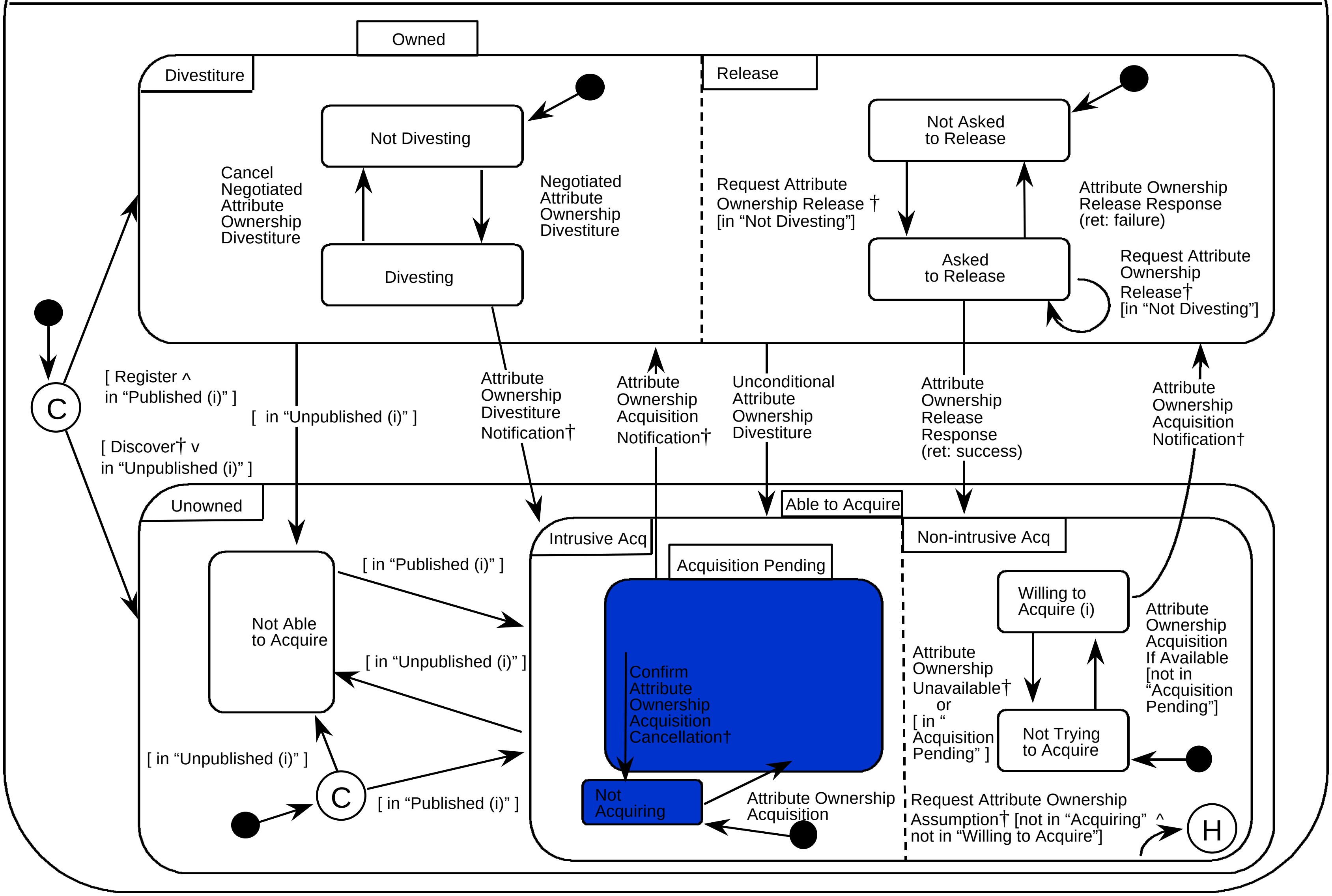
Establishing Ownership of Instance Attribute(i)


Owned
Divestiture
Not Divesting
Cancel Negotiated Attribute Ownership Divestiture
Negotiated Attribute Ownership Divestiture
Divesting
Release
Not Asked to Release
Request Attribute Ownership Release †
[in “Not Divesting”]
Attribute Ownership Release Response
(ret: failure)
Asked to Release
Request Attribute Ownership Release†
[in “Not Divesting”]
C
[Register ^
in “Published (i)”]
[in “Unpublished (i)”]
[Discover† v
in “Unpublished (i)”]
Attribute Ownership Divestiture Notification†
Attribute Ownership Acquisition Notification†
Unconditional Attribute Ownership Divestiture
Attribute Ownership Release Response
(ret: success)
Attribute Ownership Acquisition Notification†
Unowned
Able to Acquire
Intrusive Acq
Non-intrusive Acq
Not Able to Acquire
[in “Published (i)”]
[in “Unpublished (i)”]
[in “Unpublished (i)”]
C
[in “Published (i)”]

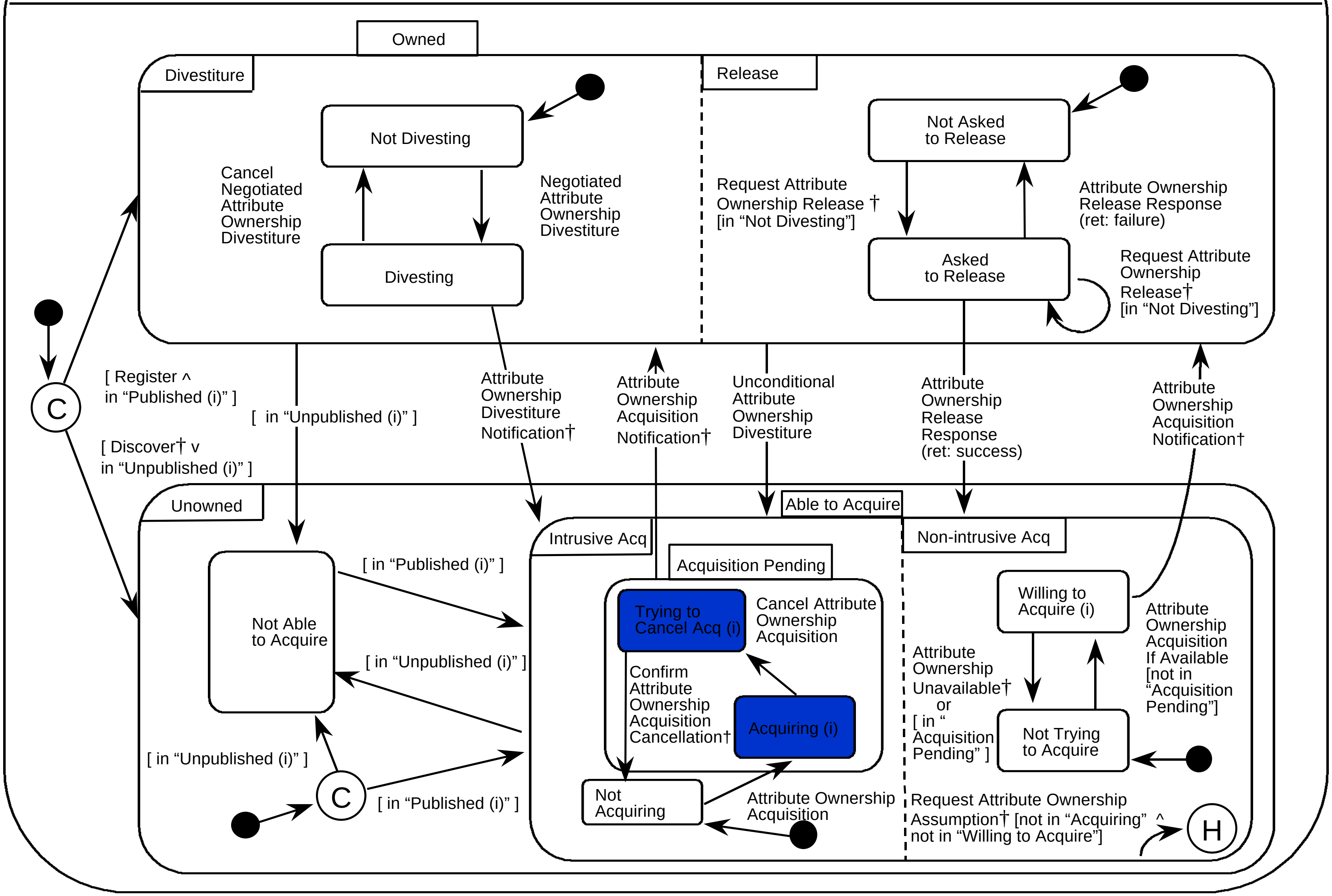
Establishing Ownership of Instance Attribute(i)


Owned
Divestiture
Not Divesting
Cancel Negotiated Attribute Ownership Divestiture
Negotiated Attribute Ownership Divestiture
Divesting
Release
Not Asked to Release
Request Attribute Ownership Release †
[in "Not Divesting"]
Attribute Ownership Release Response
(ret: failure)
Asked to Release
Request Attribute Ownership Release†
[in "Not Divesting"]
C
[Register ^
in "Published (i)"]
[in "Unpublished (i)"]
[Discover† v
in "Unpublished (i)"]
Attribute Ownership Divestiture Notification†
Attribute Ownership Acquisition Notification†
Unconditional Attribute Ownership Divestiture
Attribute Ownership Release Response
(ret: success)
Attribute Ownership Acquisition Notification†
Unowned
Able to Acquire
Intrusive Acq
Non-intrusive Acq
Not Able to Acquire
[in "Published (i)"]
[in "Unpublished (i)"]
[in "Unpublished (i)"]
C
[in "Published (i)"]
Willing to Acquire (i)
Attribute Ownership Acquisition If Available
[not in "Acquisition Pending"]
Attribute Ownership Unavailable†
or
[in "
Acquisition Pending"]
Not Trying to Acquire
Request Attribute Ownership Assumption† [not in "Acquiring" ^
not in "Willing to Acquire"]
H

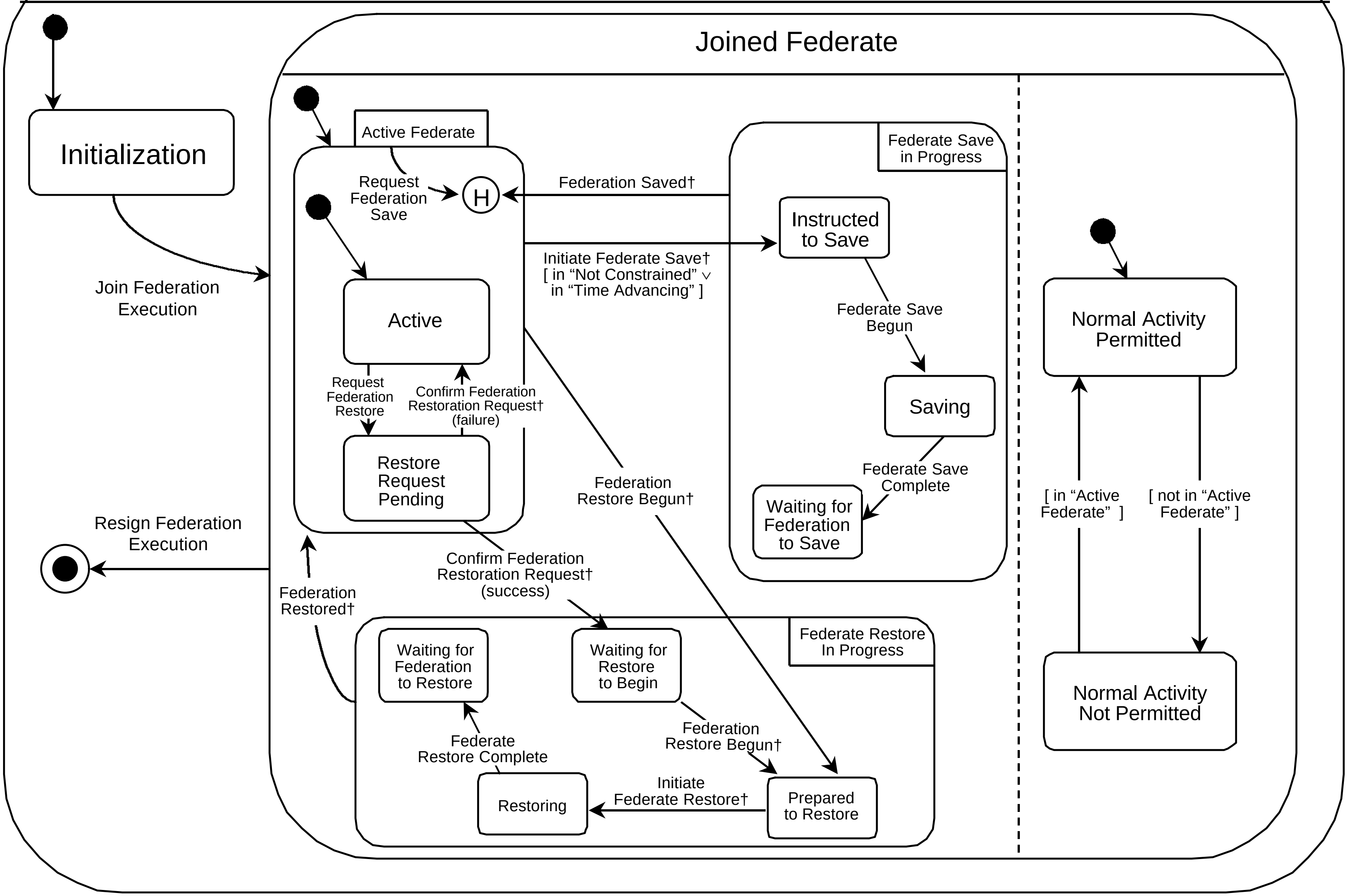
Establishing Ownership of Instance Attribute(i)


Owned
Divestiture
Not Divesting
Divesting
Cancel Negotiated Attribute Ownership Divestiture
Negotiated Attribute Ownership Divestiture
Release
Not Asked to Release
Asked to Release
Request Attribute Ownership Release † [in “Not Divesting”]
Attribute Ownership Release Response (ret: failure)
Request Attribute Ownership Release† [in “Not Divesting”]
C
[Register ^ in “Published (i)”]
[Discover† v in “Unpublished (i)”]
[in “Unpublished (i)”]
Attribute Ownership Divestiture Notification†
Attribute Ownership Acquisition Notification†
Unconditional Attribute Ownership Divestiture
Attribute Ownership Release Response (ret: success)
Attribute Ownership Acquisition Notification†
Unowned
Not Able to Acquire
[in “Published (i)”]
[in “Unpublished (i)”]
[in “Unpublished (i)”]
C
[in “Published (i)”]
Able to Acquire
Intrusive Acq
Acquisition Pending
Confirm Attribute Ownership Acquisition Cancellation†
Not Acquiring
Attribute Ownership Acquisition
Non-intrusive Acq
Willing to Acquire (i)
Not Trying to Acquire
Attribute Ownership Unavailable† or [in “ Acquisition Pending”]
Attribute Ownership Acquisition If Available [not in “Acquisition Pending”]
Request Attribute Ownership Assumption† [not in “Acquiring” ^ not in “Willing to Acquire”]
H

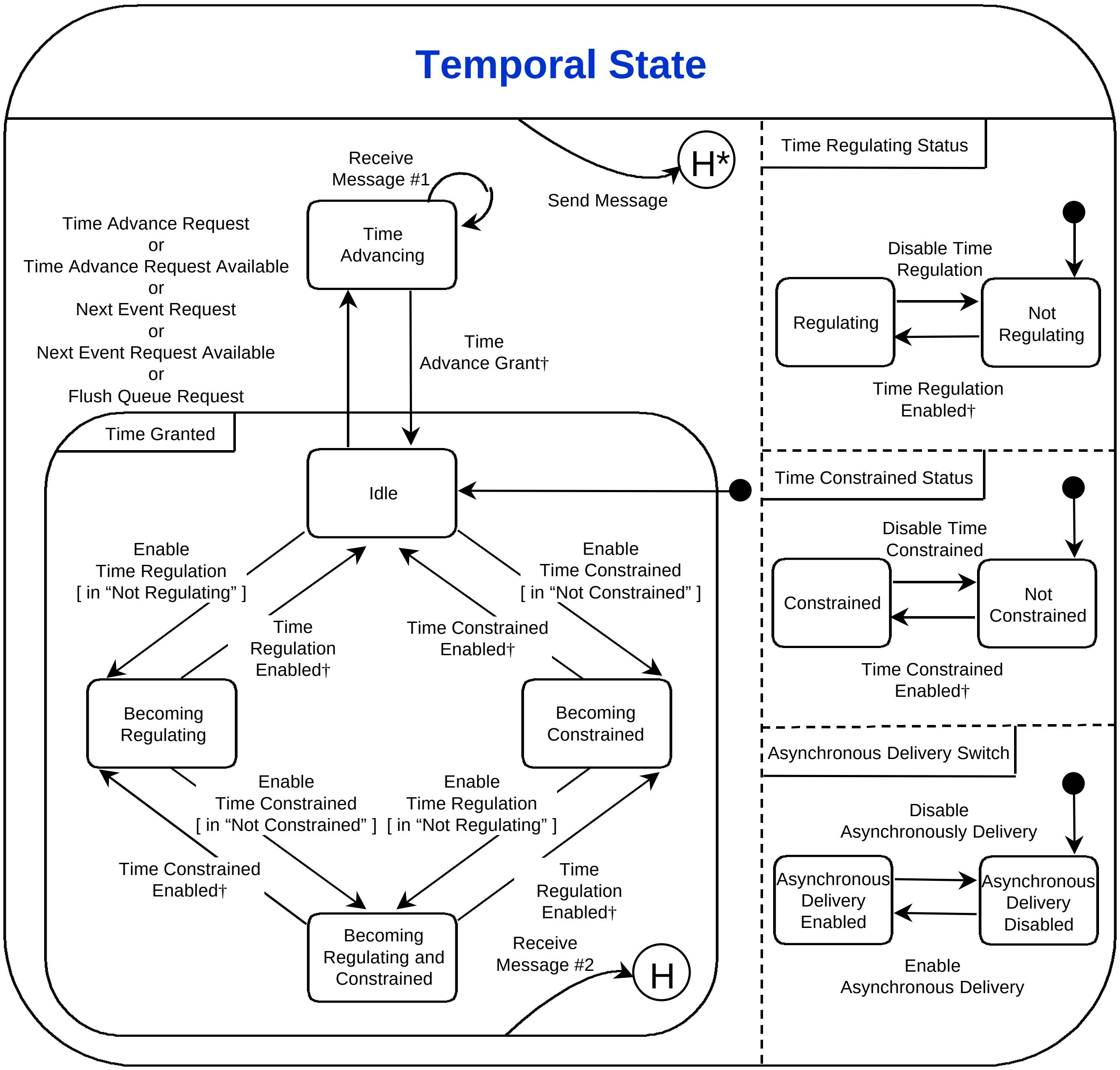
Establishing Ownership of Instance Attribute(i)


Owned
Divestiture
Not Divesting
Divesting
Cancel Negotiated Attribute Ownership Divestiture
Negotiated Attribute Ownership Divestiture
Release
Not Asked to Release
Asked to Release
Request Attribute Ownership Release † [in "Not Divesting"]
Attribute Ownership Release Response (ret: failure)
Request Attribute Ownership Release† [in "Not Divesting"]
C
[Register ^ in "Published (i)"]
[Discover† v in "Unpublished (i)"]
[in "Unpublished (i)"]
Attribute Ownership Divestiture Notification†
Attribute Ownership Acquisition Notification†
Unconditional Attribute Ownership Divestiture
Attribute Ownership Release Response (ret: success)
Attribute Ownership Acquisition Notification†
Unowned
Not Able to Acquire
[in "Published (i)"]
[in "Unpublished (i)"]
[in "Unpublished (i)"]
C
[in "Published (i)"]
Able to Acquire
Intrusive Acq
Acquisition Pending
Trying to Cancel Acq (i)
Cancel Attribute Ownership Acquisition
Confirm Attribute Ownership Acquisition Cancellation†
Acquiring (i)
Not Acquiring
Attribute Ownership Acquisition
Non-intrusive Acq
Willing to Acquire (i)
Not Trying to Acquire
Attribute Ownership Unavailable† or [in " Acquisition Pending"]
Attribute Ownership Acquisition If Available [not in "Acquisition Pending"]
Request Attribute Ownership Assumption† [not in "Acquiring" ^ not in "Willing to Acquire"]
H

Lifetime of a federate


Joined Federate
Initialization
Join Federation Execution
Resign Federation Execution
Active Federate
Request Federation Save
H
Federation Saved†
Initiate Federate Save† [in “Not Constrained” ∨ in “Time Advancing”]
Federate Save in Progress
Instructed to Save
Federate Save Begun
Saving
Federate Save Complete
Waiting for Federation to Save
Active
Request Federation Restore
Confirm Federation Restoration Request† (failure)
Restore Request Pending
Federation Restore Begun†
Confirm Federation Restoration Request† (success)
Federation Restored†
Federate Restore In Progress
Waiting for Federation to Restore
Waiting for Restore to Begin
Federate Restore Complete
Federation Restore Begun†
Restoring
Initiate Federate Restore†
Prepared to Restore
Normal Activity Permitted
[in “Active Federate”]
[not in “Active Federate”]
Normal Activity Not Permitted

Temporal State


Time Regulating Status
Time Constrained Status
Asynchronous Delivery Switch
H*
Send Message
Receive Message #1
Time Advancing
Time Advance Request
or
Time Advance Request Available
or
Next Event Request
or
Next Event Request Available
or
Flush Queue Request
Time Advance Grant†
Time Granted
Idle
Enable Time Regulation [in “Not Regulating”]
Time Regulation Enabled†
Time Constrained Enabled†
Enable Time Constrained [in “Not Constrained”]
Becoming Regulating
Becoming Constrained
Enable Time Constrained [in “Not Constrained”]
Enable Time Regulation [in “Not Regulating”]
Time Constrained Enabled†
Time Regulation Enabled†
Becoming Regulating and Constrained
Receive Message #2
H
Disable Time Regulation
Regulating
Not Regulating
Time Regulation Enabled†
Disable Time Constrained
Constrained
Not Constrained
Time Constrained Enabled†
Disable Asynchronously Delivery
Asynchronous Delivery Enabled
Asynchronous Delivery Disabled
Enable Asynchronous Delivery

Where the following transitions are expanded:

Send Message ==
RO ∧ no_ts → RO
or
TSO ∧ ts → TSO
[in “Regulating”]
or
TSO ∧ no_ts → RO
or
TSO → RO
[not in “Regulating”]

Receive Message #1 ==
RO ← RO
or
RO ← TSO
[in “Not Constrained”]
or
TSO ← TSO
[in “Constrained”]

Receive Message #2 ==
RO ← RO
(in “ Asynch Enabled” ∨
in “Not Constrained”]
or
RO ← TSO
[in “Not Constrained”]